DESIGN & DEVELOPMENT OF MIMO MICROSTRIP ANTENNA FOR IoT APPLICATIONS

Synopsis submitted to the IIMT University in partial fulfillment of the requirements for the award of the Degree of

DOCTOR OF PHILOSOPHY

In

Electronics & Communication Engineering

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1. Introduction:

MIMO Antennas:

Current trends in wireless technology is Multiple input Multiple Output (MIMO).The data capacity of RF radio system can be increased using multiple transmitting and receiving antennas as shown in Figure 1. The best benefits from a MIMO system that can be achieved is its good signal strength in the absence of line-of-sight features under deep fading conditions occurred by the different environments. The MIMO system uses 'N' number of antennas on the receiver side and transmitter side to avoid multipath fading effects. Since at the receiver end, all the signals will undergo deep fading effect whereas the proper received signal is important to increase the system performance.

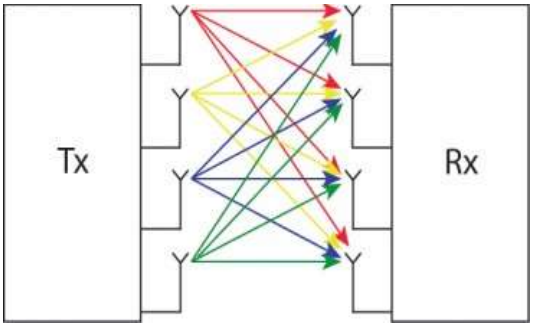


Fig. 1 Basic structure of 4 × 4 MIMO antennas

Shannon's law defines the maximum error free data rate which can be transmitted over given bandwidth in noisy environment --

$$\text{Capacity} = B \log_2 (1+S/N) \text{ Hertz}$$

Where 'B' repents, bandwidth whereas signal to noise ratio is S/N. If there are M number of spatial terms then the channel capacity is as follows

$$\text{Capacity} = MB \log_2 (1+S/N)$$

From above expression, it is clear that channel capacity is M times increased as compared to SISO. Ultimately here mentioned multiple antennas orientation are remove the effects of multi-path fading as well a high data rates can be achieved throughout in limited-bandwidth channel.

Performance Parameters in MIMO Antennas:

In MIMO antenna design, several fundamental parameters such as bandwidth, gain, efficiency, and size taken into account along with some additional parameters like isolation, ECC that is Envelope Correlation Coefficient, second is Diversity gain, third is Total Active Reflection coefficient (TARC). Acceptable range of these parameters are collected as below:

Parameter	Acceptable range
Bandwidth	3.1-10.6 GHz (± 100 MHz)
Antenna Gain	Maximum 4 dBi
Radiation efficiency	High > 70%
Group delay	Maximum 2 ns
Isolation between radiators	Minimum 15 dB
ECC	Less than 1
TARC	Less than -10 dB
Diversity gain	Near to 10
Antenna design	It is Compact, printed and easy fabrication

Table.1 Acceptable range of MIMO antennas performance parameters

2. Literature Review:

In today's digital world, we expect a high data rates and that is around 10Gbps.IoT implementation is in industries like automotive, medical, telecommunication and home appliances like AC, Fan, and Television etc. Now 5G is also developing in India rapidly. The research summary collected for my work is now presented herein 2020, Ch Murali Krishna et.al. , proposed a MIMO antenna that is hybrid model slot circular shape print and having differentiated ground of dual ports for frequencies in Ku band which ranges from 12 to 18 GHz ,X band 8 to 12 GHz, C band 4 to 8 GHz applications with little bit coverage of S & K band also. Here ,hybridized slots has been etched at radiating element which results an enhanced bandwidth from UWB to extended UWB range, that is desirable for 5G systems. In the research,HFSS simulation toolis used for design and simulation [1].In 2021, Saminathan Thiruvenkadam et.al. has presented quad-band MIMO antenna for the IoT related applications. In this work they have arranged antenna elements in chiral like pattern which results an improved isolation between them [2].In 2022, Iftikhar ud Din et.al. Presented a two-element MIMO antenna, here they have proposed a ring-shaped antenna useful in 5G IOT based applications. Firstly they have designed a single antenna element having wideband characteristics covering 4.2 to 7.5 GHz and for achieving good isolation they arranged MIMO elements orthogonally [3]. Pawan Kumar et.al in

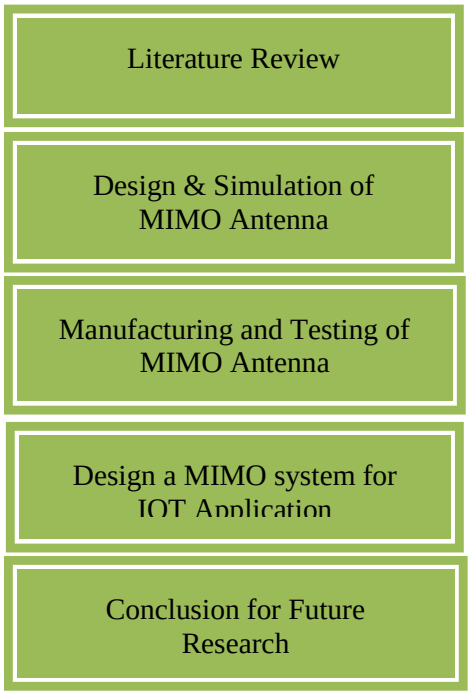
2020, low-profile, very compact shape, quad-port SWB MIMO antenna is proposed for IoT based applications. In proposed antenna, resonating elements having four identical sickle-shape is introduced, excited through tapered coplanar waveguide (CPW) feed lines [4].Gokul Nath S J et.al in 2020, proposed a monopole resonator antenna having dual band working at 2.4 GHz and 5 GHz central frequencies. For covering the two bands of WLAN (i.e., lower band at 2.4 GHz and upper bands 5 GHz), two monopoles are used, one for the lower band and the other for the higher band. Generally, there is a challenge in most of the antennas to ensure the wideband characteristic especially at the 5-GHz band of WLAN applications, when it simultaneously operating at 2.4 GHz. Here a better bandwidth achieves at the upper frequency, finally MIMO configuration results the enhanced data rate[5].Mohammad Shuhrawardy et.al, has presented a wideband MIMO antenna of 4-elements having dimensions of 25mm×30mm×0.8mm for 5G based applications. This single antenna which have a rectangular shape patch element as well as an inverted F-shaped slot with a structure having shape like chicken neck and having feed through slotted structure ground plate. This proposed MIMO system has wide bandwidth of 13.68 GHz which cover three 5G bands 28, 37, 39 GHz [6].R. Nagendra et.al. in 2021, proposed a MIMO antenna having four port, split ring resonator (SRR) with high isolation. This Tri bands antenna operate at frequencies 1.44, 2.3 and 4.2 GHz respectively [7].In 2021, Manish Sharma et.al. Presented two port, very compact size MIMO antenna with dimensions 24mm×14mm, fabricated RF Substrate Rogers RT Duroid5880 having radiator of bell-shape, printed on top plane rectangular slotted ground of chamfered edges .Bandwidth obtained here is useful for 5G 28GHz band for IoT based smart cities [8].Deepa Thangarasu et.al in 2022, presented a pin diodes based dually-polarized and reconfigurable MIMO antenna useful in IoT applications. This antenna have coverage of a wideband ranges from 3.3 to 6 GHz (5G band), it also have features of switching in between two response frequencies 2.4 GHz used in Zigbee and 5.8 GHz used in WLAN. Computer Simulation Tool (CST) is used for proposed antenna modeling and simulation [9].Mohan K N et.al. In 2021, illustrated the features of Ultra wide band MIMO antenna that for excitation uses individual common feed line. Here multiple feed sources for antenna excitation is analyzed. This MIMO system is integrated with the Wilkinson power divider. [10]

3. Objective:

1. The first goal of my work is to conduct a literature review of MIMO antennas in which past research by other researchers is identified and important conclusions like research gaps are extracted.
2. The second goal is to design and simulate a MIMO micro strip antenna for IOT applications.
3. The third goal is to manufacture the above designed MIMO antenna and go through testing for various parameters like Gain, Bandwidth, isolation etc.

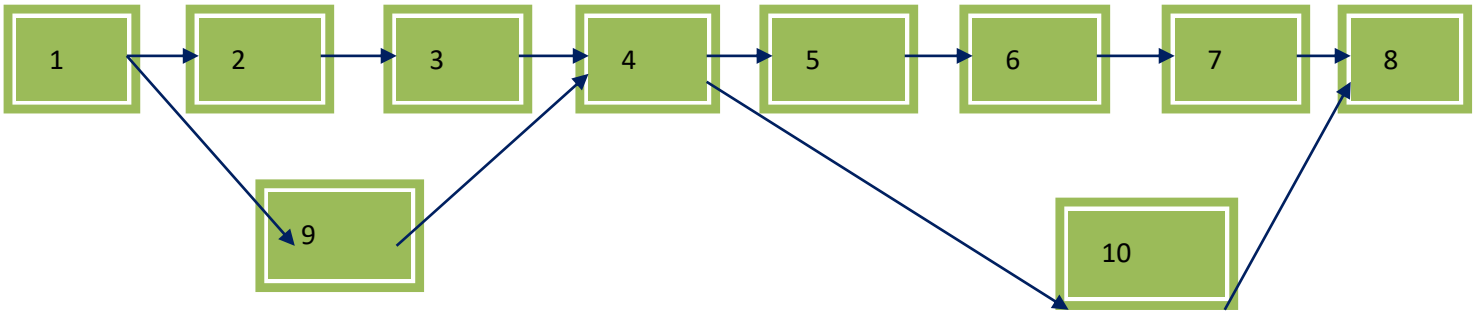
4. The fourth goal is to investigate and build an IOT based system.
5. The fifth goal is to build a system using this MIMO antenna for above mentioned IOT system and investigate it.
6. The sixth goal is to draw the conclusion from the above research work and propose some new suggestions for future researchers.

4. Research Methodology / Work Plan:


Literature Review
Design & Simulation of MIMO Antenna
Manufacturing and Testing of MIMO Antenna
Design a MIMO system for IOT Application
Conclusion for Future Research

To analyze the different IoT based models for effective and smart homes, we shall create the system which can successfully learn from its previous experiences.

PERT Chart for the proposed of the work:



1. Literature Survey
2. Study of MIMO antenna
3. Study of MIMO Microstrip Antenna
4. Study of Bandwidth Enhancement methods
5. Study of Methods of Analysis
6. Design of Microstrip Patch Antenna

7. Design Analysis.
8. Testing and Verification
9. Study and Literature Survey
10. Measurement Implementation

Major input (infrastructure for research work):

- HFSS simulation software
- PCB required (include substrate thickness)
- PCB Lab
- Network Analyzer (for testing)
- Anechoic Chamber

5: Conclusion

Multiple antenna system faces the common challenge like maintaining low cost, small size, easy to fabricate and integrated with other system circuits as in the case of single antenna development. With the growing demand of miniaturization of UWB-MIMOantenna, researchers and academician explore the novel way to optimize its parameters. On the miniaturization of MIMO antenna, their radiating elements like to be closely placed. The surface current of the excited radiating element may induce the electromotive force (emf)across the non-excited radiating element. In consequence the mutual coupling effect is raised and hence lowers the isolation between these radiating elements. Therefore, radiate or received signal correlate some extent and hence diversity performance of the MIMO antenna degrades[11]. However, to optimize this tradeoff between miniaturization and mutual coupling become a very challenging issue to develop a novel UWB-MIMO antenna. With the high isolation between many radiating elements, Ultra-wide band characteristics is also desired. To achieve these set of parameters in UWB-MIMO antenna design simultaneously is a very difficult task. Therefore, in the recent time design of miniaturized UWB-MIMO antenna with high isolation and good diversity performance become a thrust area of research for both academia and industry[12].The overall objective of the thesis is optimization of the UWB-MIMO antenna geometry with improved MIMO wide diversity performance like isolation, envelope correlation coefficient, diversity gain, total active reflection coefficient etc.

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Name and Signature of Supervisor(s) Signature of the Candidate

Counter Signature of the Head of Institute/ Organization